PRODUCTION OF CHALK FROM CARBIDE SLUDGE

BY

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CERTIFICATON

This is to certify that this project work "production of chalk from carbide sludge" which I have found adequate both in scope and quality for the partial fulfillment of the requirement for the award of Bachelor of Engineering degree in Chemical Engineering was presented by Oyelade O. Victoria 93/3716 of **CHEMICAL ENGINEERING DEPARTMENT F.U.T. MINNA.**

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DEDICATION

This project work is dedicated to my younger ones - Femi, Kola, Gbemi & Seye.

"The sky is the beginning"

ACKNOWLEDGEMENT

Hardly anyone receiving an oscar, leaves the podium without thanking all those along the way who have helped towards that moment.

To God be the glory, great things He hath done. Blessed be the name of God forever and ever, to whom belong wisdom & might. He changes times & season, he raises up the poor from dust, he lifts the needy from the ash, to make them sit with princes and inherit a seat of honour. May his name be praised.

It is my great pleasure to express my appreciation to my project supervisor, the Head of Department Chemical Engineering, Dr J. O Odigure for his time and energy spent on reviewing this work, this wouldn't have been possible without his immense contribution.

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ABSTRACT

This project focused on investigating the technological feasibility of the production of chalk from carbide sludge.

Carbide sludge was processed into dry lime hydrate by sedimentation, pressing, drying, crushing and sieving. It was observed that the optimum composition for chalk production with carbide sludge is 49.9% of $CaSO_4 \cdot \frac{1}{2} H_2O$ and 0.2% additives.

The paste was quickly poured into the mould which has been lubricated. The setting time is about 12 minutes. The chalkstick was push out of the cavity using the piston. The drying time is 7hrs at a temperature of 120^0C.

Calculations showed that the dry chalk contains about 25.4% binded water, which is equivalent to 34% of the total water added.

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CHAPTER ONE

1.0.0 GENERAL INTRODUCTION

Chalk in early and recent times has been used as writing materials on boards, and have become indispensable. Chalk has been seen as any material fashioned in form of a rod or stick which will leave a thick mark on a suitable surface.

By-product has been seen in the past as end product of production processes. Discoveries has shown that most of these by- products could be processed to produce materials that are of great value

1.1.0 HISTORICAL ORIGIN OF CHALK[1]

Chalk is a soft, fined grained, white to grayish sedimentary rock or fossil ferrous form of calcium carbonate that varies widely in colour, hardness and purity. It composed of the remains of minute organisms. Thus it is high in calcium carbonate content. Its grained size is 50um that it appears amorphous, but actually cryto crystalline with very high surface area.

Chalk deposits were formed on the floor of the ocean and consist entirely the shell of tiny aquatic animals called foraminifer. These deposits have accumulated continuously for thousand of years. The greatest chalk beds were formed during the cretaceous period.

A chalk formation extends from Northern France into the Southern part of England. Church cliffs border both shores of the English Channel. With this Britain got its ancient name of Albien (From the latin word for "white"). A notable chalk deposits, in the United States run from Augustin, texas, South West world Mexico, other large deposits, are the Niorara formation in the central great plains and the Selma chalk river in Rainfall Country, south eastern Ontorio Canada, 90miles North west of Ottawa.

1.2.0 JUSTIFICATION

The problem of waste disposal has become so prominent in developed and developing countries. Now and then, Industries are faced with the problem of depositing their waste products. For instance in the generation of acetylene gas by "wet process", carbide lime is obtained as a by-product which has to be disposed. This problem has necessitated finding the possible use of this by-product.

Carbide lime consist about 96.7% $Caco_2$ on dry basis, which can be used for several purposes. Chalk plays an indispensable role in educational development of any Nation. "Education for all by the year 2010" guarantees at least for the next decade a strong demand for chalk. It is found that only in recent times is chalk produced in Nigeria. Most of the chalk consumed are imported. Therefore to complement this, small scale industries on chalk business are springing up as a result of the discovery of row materials in the country. However, there are few chalk business, and machines are very few and the ones available are not cheap to build and operate and sometimes produce poor quality chalks that do not write well.

The need for recycling waste products increase demand for quality chalk led to this project.

1.3.0 RAW MATERIAL/EQUIPMENT

Raw material used could be obtained from acetylene generating plants. They include Boc Gases Phc Lagos. Other raw materials are $CaSO_4.\frac{1}{2}H_2O$, Binders and Pigments. The equipment mainly consists of mould, Drying oven (optional) mixing vessels, stirrer, weighing machine, crusher, screens, sedimentation tank and presser.

1.4.0 OBJECTIVES AND MOTIVATION

The aim of this project is to investigate the technological feasibility of the production of chalk from carbide sludge and also to compare with standard ones for commercial purposes. The motivation behind this project is the increasing problem of waste disposal in Acetylene generating plants

1.5.0 SCOPE AND LIMITATION

This project involves the processing of carbide lime into dry lime hydrate and the analysis on dry basis. It also involves the production of chalk from lime hydrate. The project also extends to compare output quality with existing ones for commercial purposes.

The limitations encountered in this project is with equipment to test the properties of the chalk produced, and most of the judgments were based on human preference and physical properties.

Very fine particles size would not be obtain.

CHAPTER TWO

2.0.0 LITERATURE REVIEW

2.1.0 MATERIALS USED IN CHALK PRODUCTION

2.1.1 GYPSUM[2]

Gypsum is a soft rock occurring in sedimentary layers, its colour varies from white to grey, pink or brown depending on the nature and the amount of the impurity present.

Gypsum occur in five forms all of commercial value.

1. **Rock Gypsum:-** The common form is scaly or granular. The plasterboard used by builders is made from this form of gypsum, pressed into layers with paper . This gypsum is also used in the manufacture of plate glass and water based paint.
2. **Gypsum:-** Impure, earthy form, used as fertilizers, particularly for peanut crop of the southern United States.
3. **Selenite:-** Is a transparent crystal form, used for inexpensive jewellery.
4. **Alabaster:** Is a soft, compact, fine grained form of gypsum (calcium sulphate) that is easily carried. Its slightly translucent and it colour usually ranges from white to pink. Alabaster is used to mold status, used as lamp bases, level boxes and other ornamental object. These objects can be made as hard as marble by being subjected to intense heat. Gypsum is anhydrous calcium sulphate with the formula $CaSO_4.2H_2O$.

2.1.2 PLASTER OF PARIS

It is originally made from gypsum fund in Paris [3]. Notable producer in Nigeria include Africa mining, limited in north, Maico consultant limited & Karvitex in Lagos. Plaster of Paris is available in the market for direct use. Thus the entrepreneur can decide to buy directly from the place mentioned above or from other producer, or set up his own unit of producing it.

2.1.3 CALCIUM CARBONATE [(4)]

This is a white precipitation from limestone or natural chalk. It is mixed with certain organic and inorganic binders, to fashion into chalkstick. Its origin can be traced back to natural occurring chalk. Dimorphous and crystallizing in various form, hexagonal system as calcite (Density 2.7) and Aragonites (Density 292) calcite is the most common form of calcium carbonate, besides occurring in mineral, it forms the calcium constitutes of egg shell and bones (together with calcium phosphate all of which effervescence with acids. A compound of calcium carbonate and magnesium carbonate is dolomite, $MgCO_3$, Limestone, chalk and marble are variety of calcium carbonate. On strong heating it forms quicklime, which is strongly basic and is appreciably soluble in water to form an alkaline solution.

$$CaCO_3\,(s) \xrightarrow[(900^0C)]{} CaO(s) + CO_2(g)$$

$$CaO\,(s) + H_2O\,(1) \rightarrow Ca\,(OH)_2 \quad (1)$$

2.1.4 LIMESTONE [5]

This Rock contain chiefly calcium carbonate and a variety of quantities of magnesium carbonate, it also contains argillaceous material (clay containing material silica and iron in smaller quantities. Limestone varies greatly in colour and texture. The texture ranges from dense and hard limestone e.g. marble or travertine, which can be sawed and polish for use as decorative stone. It is an impure deposition of clay and sand.

2.1.5 NATURAL CHALK [5]

This is a variety of limestone form, from pelagic or floating organism that is very fined grained porous and friable . It is white or very light colour and consist almost entirely of calcite [6]. It grain size is so minute that it is amorphous, but actually is a crystalline with high surface area. The best known natural chalks are those of cretaceous exposed in cliff, it is used for cement powders, as soft abrasive and polish, crayons, fertilizer and anticracking agent.

2.1.6 KAOLIN [6]

This is a very useful mineral for industrial manufacturing process. It is an hydrated alumunium silicate, having the formular $AL_2O_3.2SiO_2.2H_2O$. It is formed by the hypogenication of granite rocks resulting from the action of super heated steam and hot gases emitted from the core of the earth [5] . The chemical action of these acid decomposes the granite rock to form kaolin mineral, which is white, soft, powdery, refractory, and having Mica, quartz, iron oxide, MgO, CaO, as impurities. Kaolin is commonly called China clay

2.1.7 ALTERNATIVE RAW MATERIALS [3]

Chalk can be produced from oyster shells otherwise known as sea corals. They are found deposited beneath the bed sea having being accumulated for many years as a result of the decomposition of some invertebrates and small sea animals [11] . The production involves five stages.

(i) Production of carbonate water from dilute hydrochloric acid (HCl) and (Sodium carbonate)

(ii) Production of starch from cassava tubers.

(iii) Separation of needed calcium carbonates from the oyster shell (sea corals) It involves washing to remove coloured impurities, drying in an oven, crushing, grinding and forming a slurry to get the calcium carbonate extracted.

(iv) Getting a suitable mould.

(v) Mixing the starch (i.e binder) and the calcium carbonate in appropriate ratio and drying. (oven or sunlight)

2.1.8 CASTING THICK SUSPENSION [10]

A thick suspension of chalk batch is made with the following[10]

Calcium carbonate	44% by weight
Talc ($3MgO \cdot 4SiO_2 \cdot H_2O$)	3% by weight
Kaolin	3% by weight
Water	50% by weight

The batch is thoroughly mixed and when suspension begin to thicken, it is cast into the mould. As soon as the mixture set, it is compressed in place by bringing down the ejector to exert some pressure, and the chalk is sun-dried.

USING PLASTER OF PARIS [7]

A thick suspension can be made using the following

Calcium sulphate (P.O.P)	47 %
Water	50%
Additive (coloured and Binder)	3%

2.2.0 LIME SLUDGE AS RAW MATERIAL

2.2.1 CARBIDE LIME TECHNICAL DATA AND AVAILABILITY[8]

Carbide Lime is a by-product obtained in the generation of acetylene gas from calcium carbide. It is variously referred to as carbide sludge, generator slurry, lime sludge, lime hydrate, and other such designations. Carbide lime is better described as by-product of predominantly calcium hydrate from acetylene generation or simply carbide lime.

By-product calcium hydrate is found wherever acetylene is produced from calcium carbide. The calcium carbide employed from the generation of acetylene is manufactured from the reduction of high quality lime by the carbon of the selected cokes in high temperature of carbide electric furnacing process. Production of acetylene (C_2H_2) is accomplished by the reaction of calcium carbide and water in properly designed acetylene generating equipment. In this process, acetylene of the highest purity is obtained from the carbonate of the carbide and the hydrogen of the water. The process also produces the subject carbide lime or by-product calcium hydrate [$Ca(OH)_2$], the latter obtaining its calcium from the carbide and hydroxide radical from the oxygen and hydrogen of the water. The chemical equation is given below

$$CaC_{2(s)} + 2H_2O_{(1)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(ag)}$$

Carbide lime is a potential top grade hydrate lime because of the high quality of the original raw materials of the process, and because of the very nature of the electric furnacing and acetylene generation steps through which the lime must pass.

By-product calcium hydrate from acetylene generation is a source of high calcium lime. Its economic and chemical usefulness is potential comparable with that of commercial lime and hydrate lime in all field of agriculture and farming, in building and construction, in industrial and chemical process.

TYPICAL CHEMICAL COMPOSITION [8] TABLE 2.1.1

CALCIUM HYDRATE ANALYSIS

(Dry Basis)

	Acetylene generator By-product Hydrate		Commercial hydrate	
			Sample	Sample
	Generator	Pond	1	2
$Ca(OH)_2$	96.50	92.22	96.44	92.40
Available CaO	(73.00)	(69.80)	(72.50)	(69.90)
$CaCO_3$	1.25	2.82	1.76	3.80
SiO_2	1.10	1.46	0.81	1.30
$R_2O_3(Al_2O_3.Fe_2O_3)$	0.50	2.66	0.38	0.90
$Mg(OH)_2$	0.25	0.16	0.57	1.40
S	0.15	0.17	0.03	1.01
P	—	0.01	0.01	0.01
Free carbon	0.25	0.25	—	—

COLOUR,ODOUR AND FOREIGN MATERIALS [8]

It is to be recognized that carbide lime is a "by product" as produced by the carbide acetylene process, slight variations in chemical analysis and presence of alien matter will exist depending on local conditions at the point of production. The by-product hydrate has a grayish colour and a characteristic acetylene odour as it comes from the generator, this odour passes away with time, but the grayish colour results largely from the very small percentage of combined sulphur contained in the slurry and small amounts of ferrosilicon and carbon.

PARTICLES SIZE AND MAGNESIUM CONTENT[8]

Carbide lime is extremely fine in particle size, and usually finer than most commercial hydrate limes. It has a number of advantages, such as

1. **Complete hydration (8): -** That is, freedom from unslaked lime because it is made in many times its own weight of water, while ordinary hydrate lime is made with only a fraction of its own weight of water in order to avoid subsequent drying which is inconvenient and expensive.
2. **Fine state of sub-division or fineness**. In a published test (8) of dried carbide lime, 99.9% passed through 300um mesh sieve, in another series of test, 92 to 98% passed through a 325um mesh sieve, while ordinary commercial hydrated lime does not show as good a percentage through a 200um mesh sieve. This extreme fineness is caused by the nature of formation from calcium carbide. The acetylene on liberation has a tendency to crack or break open ordinary fine grains of lime into still smaller particles. The heat and excess water in the generation also present ideal conditions for the production of very fine particles of hydrated lime. The finer subdivision is particularly valuable, where carbide lime is used in the chemical, industrial and construction fields of usage.
3. **Low Magnesium Content:-** There is only a trace of magnesium present because the lime originally used in making calcium carbide must be extremely low in magnesium. Low magnesium and high calcium are the resulting magnesium products dissolved very

readily in water, while calcium product are insoluble and can easily be removed by precipitation.

4. **Price:** Users of hydrated lime can in many instances effect a saving of one third to one half of their present expenditure for lime, by arranging to secure carbide lime from a nearby acetylene generating plant. A very high grade of by product-hydrated lime can be purchased at attractively low prices.

5. **Bulk density vs Percentage Solids** [8]**:-** The following are typical weight ratio and density data of carbide lime at various percentages of solid content based on a specific gravity of solid of 2.14.

TABLE 2.2 BULK DENSITY VS PERCENTAGE SOLID

Solid content (%)	Weight ratio, Ib carbide lime per Ib available CaO	Density Ib per gallon
10	14.4	8.8
20	7.3	9.3
30	4.8	9.9
40	3.6	10.6
50	2.9	11.4
60	2.4	12.3

6 **Percent Solid VS Available CaO.** The available calcium oxide content of carbide lime is often the gauge by which its value or usefulness is measured. By-product calcium hydrate has a higher available calcium oxide content than many high grade commercial hydrate limes. The following are typical data relating percent solids of carbide lime per ton of available CaO.

Table 2.3.0 [8]

Solids Contents (%)	Available CaO gal. Carbide lime per Ton
10	3,300
20	1,560
30	960
40	670
50	510
60	400

7. **Handling and Pumping-** Pumping of carbide lime has been demonstrated to be feasible in the solid concentration as high as 40 percent. Carbide lime with a solid content in the range of 50-60% is amenable to digging and truck hauling. Tank truck or car haulage of lesser solid content slurries has been demonstrated satisfactorily.

   Handling and Transportation- Water slurries of carbide lime, containing up to 40 % solids by weight, are fluid enough to be pumped satisfactorily with standard type centrifugal pumps. At about 50% or more solid content, the concentration reached by prolong pond settling, the consistency of the carbide lime is that of a fairly firm putty which can be handled effectively by digging with power shovels. Carbide lime in the intermediate 40-50% solid content semi-fluid state can either by fluidized for pumping by adding water or be further concentrated to a putty firm enough for shoveling by continued settling and decanting.

8. **Fineness vs Settling:-** In spite of the fineness of carbide lime particles size, the solid of a slurry are generally many times faster settling than the solid of a water lime mixture made directly from burned lime. This difficulty can be overcome by using a surge tank with agitator in most cases. If the later method proves inadequate under certain process conditions the difficulty may be overcome by

grinding wet slurry in a colloid mill. When so treated, it is known that the slurry can be held in storage tanks for a week or more without appreciable settling and in addition is less apt to clog values or lines of a pumping system.

2.2.2 PRODUCTION OF P.O.P FROM LIME SLUDGE [9]

Plaster of Paris (P.O.P.) can be produced synthetically from carbide sludge, which is one of the materials used in chalk production carbide sludge which consists of mainly of calcium hydroxide and the early impurities such as charcoal (Carbon) and Sand that come from carbide ore.

There two methods of synthesizing the P.O.P. from carbide sludge. The direct and indirect method. In the direct method, the sludge is reacted straight away with dilute sulphuric acid. The equation for the reaction is given thus-

$$Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

This $CaSO_4$ is also known as synthetic gypsum. The other method is known as indirect method. This involves first converting the calcium hydroxide to calcium chloride which is highly soluble in water which through filteration enable the separation of all impurities present and the resultant clear solution is reacted with dilute hydrochloric acid. The equation of the reaction is given thus:-

$$Ca(OH)_{2(s)} + 2HCL_{©} \rightarrow CaCl_{2(ag)} + 2H_2O_{(1)} + \text{impurities}$$

$$CaCl_{2(ag)} + H_2SO_{4(l)} \rightarrow CaSO_4 + 2HCL_{(1)}$$

The precipitated calcium sulphate is washed cleaned of hydrochloric acid and first dried to gypsum. The calcium sulphate of the indirect method was found to be in the purest form. This calcium sulphate can be dried to gypsum and roasted to plaster according to the reaction

$$CaSO_4 + 2H_2O \rightarrow CaSO_4.2H_2O$$

$$CaSO_4 + 2H_2O \rightarrow CaSO_4.\frac{1}{2}H_2O + 3/2H_20$$

This roasting process is known as calcination and the method used in calcining will determined the type of product obtained. If the gypsum is crushed to smaller sizes and heated in a kettle with 30% solution of calcium chloride harder materials suitable for manufacturing porcelain, ceramic is produced [4]

2.2.3 PRODUCTION OF $CaCO_3$ FROM LIME SLUDGE (12)

Calcium carbonate can be produced synthetically from carbide sludge, which is one of the oldest material used in production of chalk.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

This experiment is performed by dissolving the dried and grained $Ca(OH)_2$ in water, and stirring continuously until the required solution is obtained. Depending on the quantity of CO_2 to be used for reaction. For example, 12.5 kg of grinded sludge is dissolved with 130 litres of water and 7.5kg CO_2 filled inside a cylinder is bubbled into the solution. A precipitate of $CaCO_3$ is obtained with when dried contains over 88% $CaCO_3$. About 98% of the water used is recovered which shows that water does not take part in the reaction. An analysis of the sample is given below

TABLE 2.4 ANALYSIS OF $CaCO_3$ SAMPLE (10)

PARAMETERS	PERCENTAGE
Calcium Carbonate $CaCO_3$	88.82
Calcium Hydroxide	1.48
Silical carbon (as impurities)	3.06
Ferrous (as Fe^{2+})	0.26

2.2.4 REACTIONS OF CALCIUM HYDROXIDE[8]

* Calcium hydroxide $Ca(OH)_2$ can be obtained from calcium oxide by the reaction of CaO with water.

$$CaO_{(s)} + H_2O_{(1)} \rightarrow Ca(OH)_{2(s)} \quad \Delta H -65kj/mol$$

* Calcium oxide or quicklime can be obtained from calcium hydroxide by heating at a temperature of 309^{0c}

$$Ca(OH)_{2(s)} \rightarrow CaO_{(s)} + H_2O_{(g)} \quad \Delta H \quad 109kl/mol$$

* Calcium hydroxide is used to neutralize acidic soils, soften hard water.
* It is used to produced mortar which is an important building material formed by mixing calcium hydroxide with sand and water. The water evaporates and the mixture sets hard. The setting process takes place because calcium hydroxide absorbs CO_2 from the air and thus converted to calcium trioxocarbonate(iv)

$$Ca(OH)_{2(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$$

* As a base, Calcium hydroxide is a weak base, reacting with acids, acidic oxide and ammonium salts.

$$Ca(OH)_{2(ag)} + 2HCl_{(gg)} \rightarrow CaCl_{(ag)} + 2H_2O_{(l)}$$

$$Ca(OH)_{2(ag)} + 2NH_4Cl_{(s)} \rightarrow CaCl_{2(ag)} + 2H_2O_{(l)} + 2NH_{3(g)}$$

* If carbonate is bulked through water, calcium-trioxocarbonate(iv) is precipitated.

$$Ca(OH)_{2(ag)} + CO_{2(G)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$$

* The precipitate will disappear if more CO_2 is bubbled through the solution. Calcium hydrogen trioxocarbonate (iv) is formed which is soluble.

$$CaCO_{3(s)} + CO_{2(g)} + H_2O \rightarrow Ca(HCO_3)_{2(aq)}$$

* With chlorine[8]

If chlorine is bubbled through a cold saturated solution of calcium hydroxide, calcium -oxochlorate (bleaching powder) is formed.

$$2Ca(OH)_{2(ag)} + 2Cl_{2(g)} \rightarrow Ca(OCl)_{2\,(ag)} + CaCl_{2(aq)} + 2H_2O_{(L)}$$

(Bleaching powder)

2.3.0 MAKING OF CHALKSTICK FROM HYDRATED LIME

2.3.1 PROCESSING OF HYDRATED LIME FROM CARBIDE SLUDGE

In the generation of acetylene from calcium carbide, the later reacts with water in a "wet" generator, to produce a slurry of calcium hydroxide (hydrated lime). The solid concentrate from the wet generation is between 10 –12%. It is possible to concentrate this slurry to about 30 – 40% solids by decanting or by the use of mechanical thickener. 45 – 55% solid center produced by prolonged pond settling. Commercial operations have demonstrated that slurry can be concentrated satisfactorily up to 60% solid in a centrifuge. Experimental tests have indicated that drying of 60% solid to a moisture content of 1-3% can be accomplished in a flash drier without excessive carbonate formation. [(8)]

Commercial operations has further demonstrated that 60% solid hydrate can be calcinated in a rotary klin to produce a high quality calcium oxide of unusual reactivity; the product is inherently of extreme fine particle size and may be produced either in agglomerated or briquette form. [(8)]

Dilute or concentrated slurry can be dried effectively by mixing it with quicklime. The surplus water in the carbide lime slurry slakes the quicklime such that the percent solid of the resultant mixture is appreciably increased even to the extent of achieving commercially dry hydrate. This is accomplished in a process consisting essentially of a slurry tank with manually controlled discharge, a quicklime feeder and a mixing tank or hydrator. The quicklime hydration develops considerable heat, which acts to vaporize some of the water and volatile impurities of the carbide lime [(8)]. The resultant hydrated lime product is completely free from sulphide & objectionable odour and is amendable to further processing as to improvement or physical sizing and hence it is suitable for various end uses in chemical, industrial, building or agriculture field.

For this project, decanting method is selected because of the easy simplicity and low cost.

2.3.2 CASTING OF HYDRATED LIME

Hydrated lime is mixed with plaster of paris and water at room temperature. The mixture is thoroughly stirred, to ensure complete mixing and removal of air bubbles. It is poured immediately into the mould as soon as mixing is completed because it sets fast and will form a solid crust of any shape it finds itself.

The grain fineness, operating temperature, amount of stirring determined how fast the mixture sets. Another vital determinants of the setting time is the presence and amount of chemical substances which acts as retarder (slows down the reaction eg Animal glue) or accelerator (speed up the reaction eg Aluminum Allum); potassium sulphate (K_2SO_4) and Ammonia sulphate $(NH_4)_2 SO_4$

It takes about 15 minutes for the mixture to set. The setting time also depends on the ratio of hydrated lime to plaster of paris, because plaster of paris has a stronger binding property. Accelerators can be added to increase the setting time, but some accelerators have some bad features which makes them undesirable [8].

2.3.3 MOULDS FOR CASTING CHALKSTICK [10]

The type of mould used in casting chalkstick will determine the surface roughness and smoothness of the chalk. Moulds can be made from metal, plaster of paris, lime mortar etc. The surface feature of the mould is very important because it determines the type of chalkstick that will be obtained since it takes the shape of the mould. When wooden moulds are used, heavy oil may be used as a thin layer to prevent sticking. For metallic mould, lubricant is necessary especially for plunger surfaces.

A cheap lubricant is made by mixing hard oil and some other oil, which contain stearin, palm oil or olive oil could be used. There are now also new chemicals, which can be used as lubricating agents or parting agents to separate the object from the mould. One of such is methyl – phenyl silicon fluids [10].

It is possible to used a "gang mould" namely a large mould with a number of holes in a line each hole being a mould for a single chalkstick, here the casting slip is poured rapidly into the individual moulds and the excess can be remove from the mould by a simple movement of blade or knife. Such device could be held firmly in position in a machine, having a group of plunger operated vertically to push the chalksticks upward [10]

COMPRESSION MOULD

They are machines having metal mould equipped with two vertical plunger for each chalkstick mould. With the bottom plunger in place, the mould is filled with the chalk – paste, and as soon as the mixture sets, it is compressed in place by bringing down the upper plunger to exert pressure of several hundreds Newton per square metre of Area. The upper plunger is then released and the chalkstick is removed by being pushed upwards by means of lower plunger. The mould part are lubricated and the entire operation repeated.

2.3.4 BINDING MATERIAL

ORGANIC BINDERS [11]

Organic binder can be employed in making of chalkstick by two processes, (extrusion and pressing). The binder put the chalk particles together and hold them in place to form consolidated and compact solid mass in the finish shape.

There are numerous natural occurring & synthetic organic binders, [11] they include:

(a) Flour (extrusion and pressing)

(b) Starch (extrusion and pressing)

(i) Cassava (ii) Potatoes (iii) Corn

(iv) Rice (v) Wheat

(vi) Dextrin made by heating starch

(c) Natural gum (pressing)

(i) Arabic (ii) Tragacth (iii) Acacia

(iv) Karaya (v) Locust seed (vi) Agar – Agar

(d) Alginates

From seed weeds

(e) Wood extract (pressing) eg Lignius

(f) Alcohols (extrusion, pressing)

Polyvinyl alcohol (synthetic)

(g) Cellulose product (pressing)

(h) Paraffin waxes (melting point 110^0C)

(i) Bee wax

(ii) Carnauba wax

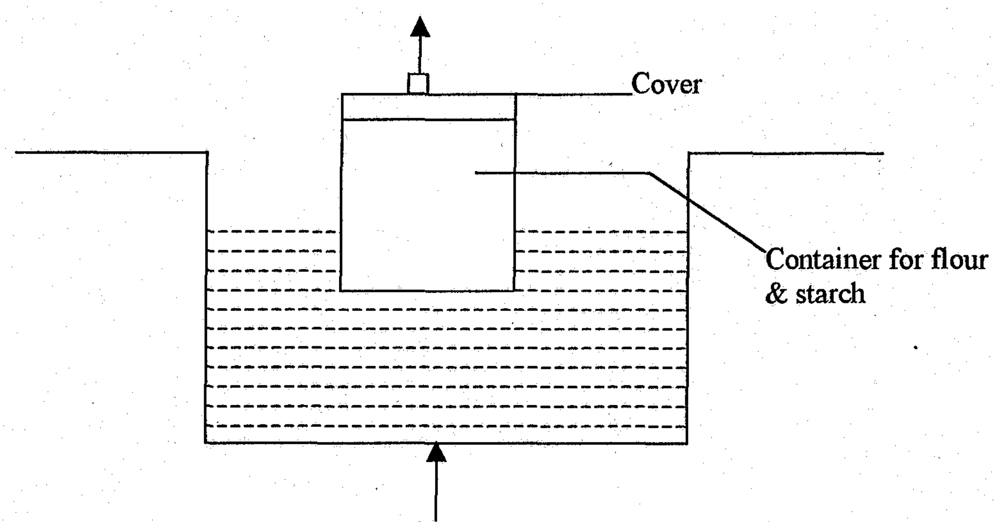
2.3.5 BINDERS (DEXTRINS) [11]

FLOUR & STARCH [11]

Flour and starch paste make good plasticizer and binders for powdered materials such as natural chalks needed to make chalk stick either by extrusion of pressing processes . A very convenient method of preparing the stable is to use double boiler as shown in the diagram below.

A bath can be made out of any iron vessel. The container and cover is then place and suspended in the water bath; the flour and cold water in the container are weigh or measured and mixed to break up lumps by stirring. The container is then covered and placed suspended in the water bath; which then heated to boil gently. The content are stirred once in a while to prevent lumping and to ensure homogeneity. During the process the original thin suspension will be converted into a transparent gel, when the gel has formed, the container should be removed from the water bath and allow to cool at room temperature. [9]

For the formation of best structure the gel should be aged overnight before use. If the paste is kept for sometimes, it is necessary to add preservatives, to prevent the formation of mould, which accompanies deterioration of the paste. Keeping the paste in a cool place or in a refrigerator will help prolong it's usefulness. Concentrated ammonia water not only acts as preservative but also aid in development of plasticity [9] but, however, ammonia is not absolutely necessary as phenol or benzoic acid may be used as preservative. Below are formula process that have been used.



(a)	Wheat flour paste	By weight %
	Weight flour	2.5 – 5.0
	Water	95.5 – 95
	Ammonia Conc.	2.0
		100
(b)	Corn starch paste	By weight %
	Corn starch	2.5 – 5.0
	Water	97.0 – 94.5
	Vinegar 5% Acetic acid	0.5 – 0.5
		100

2.3.6 PIGMENTS & COLOURANTS

Pigment are coloured organic substance, widely used as surface coatings. They are also employed in ink, plastic rubber ceramic, paper and chalk to impact colour. [20]

A large number of pigment are consumed because different product require a particular choice of material to give a maximum coverage and the desired acceptance.

White lead, zinc oxide, and lithophone are once the principal white pigment [20], colour pigments constitute lead chromate and various iron oxide of transition metals. This is due to the ability of transitional metal to form coloured. [26]

Today different variety of processed pigment called colorants are found commercially in the market, equally this colorant are used in impacting colour to chalk stick during chalk production.

2.4.0 THE GREAT UTILITY OF LIME [12]

Utility of carbide lime, one of the highest authorities on the subject of lime and its uses set forth the following observation on the subject, all of which has equal applicability to the utility of carbide lime.

The great utility of lime has not been generally known, and the general impression prevails that lime is merely a cheap building material that may be used in a few technical processes. It would lead to important economic betterment if the scientific, industrial, and business world realized that of all the nation's raw materials and manufactured products, none is more richly endowed as lime with intrinsic merits and capacities for broad application to our industrial and farm life.

"Lime is much more than a building materials[8]. It is a chemical and a most versatile one. It is distinguished first of all by the large number of different functions that it will perform. In its construction uses, it performs at least nineteen different functions. In its chemical uses, the number is much larger, and there remain many others that may reasonably by expected to result from the systematic research and experimental work now being carried on in the matter of lime and its properties".

By-product calcium hydrate from acetylene generators is always a potential source of high calcium lime because of its high reactivity and fine particle size.

Whenever lime or hydrated lime is used there is a potential possibility that carbide lime will satisfy the need for the oxide or calcium.

2.4.1 USES IN CHEMICAL – INDUSTRIAL FIELDS [8]

(i) Carbide lime for bleaches: Bleaching powder or bleaching solution is made from slaked lime or milk of lime and chlorine. Carbide lime gives a good source of milk of lime for this purpose.

(ii) Carbide Lime As Dechlorinating Agent: Milk of lime is used as a dechlorinating agent in the manufacture of trichloroethylene, perchloroethylene, ethylene oxide, ethylene glycol, and other organic chemicals. By-product calcium hydrate has been successfully used in a plant manufacturing trichloroethylene, its use in the production of ethylene glycol has been proved by test.

(iii) Carbide Lime for Pulp and paper Manufacture:- There are many uses for lime in the pulp & paper industries. Rags for the manufacture of paper are cooked in a digester under steam pressure with lime or with lime and soda ash. The standard quicklime for use in cooking rags must contain at least 90 per cent quicklime [(CaO) A.S.T.M.C_{45-25}]. By-product calcium hydrate, easily meeting this purity requirement, is a good source of lime for this use.

(iv) Carbide Lime For Paint & Vanish Manufacture: Paint and varnish manufacture requires the use of lime. It is used to neutralize the acids and clarify varnish and as a resonate in paints. Consistent with the removal of alien particles, carbide lime should be a suitable source of lime for this purpose.

(v) Carbide Lime in the Petroleum Industry:- Milk of lime had been used in oil refineries for the washing of refinery gases for the removal of various forms of sulphur and diminution of the latter is corrosive effect on equipment.

(vi) Carbide Lime Water Purification: Treatment of water for drinking purpose varies considerably with source of the water. In certain cases the water must be "purified" and "temporary hardness" reduced. Lime has been found effective in treatment of unpalatable water due to presence of phenol and for reducing hardness.

(vii) Carbide Lime for Sewage Treatment:- By product calcium hydrate as a coagulating material in sewage treatment is being used with completely satisfactory results. Ferric chloride and quicklime have been customarily added at one point. In the sewage treatment process to form a coagulant to facilitate dewatering of the sewage sludge. Carbide lime has replaced the quicklime and commercial experience has shown that a considerable savings resulted in the cost of lime because the generator slurry has a lower cost source of lime and equally as effective as the quicklime which has to be hydrated before it use.

(viii) Carbide Lime for Neutralization of Acid Wastes: Acid in chemical and industrial wastes can be effectively neutralized with by-product calcium hydrate. Many installation now use quicklime, hydrate lime or lime-stone. Carbide lime is preferred because of its low cost.

2.4.2 USE IN THE BUILDING AND CONSTRUCTION FIELDS [8]

General considerations: Quicklime or hydrate lime is used in the building industry. If quicklime is used it must be very carefully and completely slaked before using . It is also desirable to soak hydrated lime before using. The formation of by-product calcium hydrate by the reaction of calcium carbide with large volumes of water could be used in place of commercial fresh hydrated lime for this usage.

(i) Carbide Lime in the Aluminum Industry: Dry carbide lime, as a replacement for virgin lime, is used extensively and successfully in the aluminum industry. It is use in conjunction with soda ash, as a causticising agent for the wining of alumina from bauxite.

(ii) Carbide Lime in the Leather Industry:- In the leather industry lime is used in the depletion (hair removing) process. The skins are soaked in vats containing milk of lime, arsenic sulphide, sodium sulphide and sometimes sodium hydroxide. The lime should contain a minimum of 85% CaO and have a low iron content. By - product calcium hydrate is a good material for this used.

Carbide could also be used in metallurgical fields, carbide lime for by-product coke plants, for glass manufacture.

2.4.3 USES IN FIELD OF WATER SOFTENING, SEWAGE AND ACID TREATMENT. [8]

(i) Carbide Lime for water softening Lime, or a mixture of lime and soda - ash, is used extensively for softening . When water contains considerable quantities of bicarbonates and sulphates of calcium and magnesium it is hard. The bicarbonates produce what is termed "temporary hardness" when excess lime is added, the bicarbonate form carbonates which are much less soluble in water and a precipitate is formed which is removed by filteration. Carbide lime, can be used for all or part of lime used for the softening of water. By direct pumping of the slurry to water treating vats substantial saving in costs of lime and labour of handling lime in acetylene generators assures that it is completely and properly slaked. With respect to this particular quality requirement it would therefore follow that by-product calcium hydrate meets full requirements for use in the building industry in place of other forms of lime.

Physical properties of the hydrate such as plasticity, sand carrying capacity, strength when mixed with sand, time of set, and color are equally important properties to consider for building industry uses. By-product calcium hydrate of desired water content, generally meets these requirement except perhaps were colour is critical factor, according to A.S.T.M specification C_5 - 59 for lime structural purposes, the chemical composition must conform to the following

CaO minimum	75%
CaO, plus MgO, minimum	95%
Silica Iron, etc maximum	5%
CO_2 Content, maximum	10%

By - product calcium hydrate will meet the above specifications and has also been found satisfactory as to particle size.

(iii) Mortar Using Carbide Lime: Mortar is made by mixing lime putty with sand and water. The lime putty is made from quicklime or hydrated lime. By - product calcium hydrate, properly concentrated, is high quality lime putty. The quality of mortar depends on the method of its preparation as well as the characteristic of the lime. A high calcium lime properly burned (by - product hydrate is of this character) yields the greatest volume of mortar per weight of materials.

Proper slaking has more to do with the mortar slaking properties of a lime than any other single factor. By - product calcium hydrate is unusually well slaked because it is made in many times, it own weight of water and considerable time usually elapses between the time of discharge from the generator and its use in mortar. Because of it extreme fineness & complete hydration, mortar made with carbide lime spreads more smoothly with less effort and has much "pull" to its as the average grade of high magnesium hydrated lime, while it has the added advantage of greater density and more lasting resistance to weather conditions.

Carbide lime is frequently accepted as a satisfactory substitute for lime in mortar for structural purpose; its use in specific cases may be subject to approval by construction authorities.

(iv) Carbide Lime for Plaster: Lime plaster is made by mixing lime putty and sand, with or without hair. By-product calcium hydrate, in place of other form of lime, is suitable for making plaster, because of its well slaked nature and fine particle size. It is also suitable where whiteness is not a controlling factor. It used in scratch and brown sub-coats should be entirely acceptable.

Carbide lime has long been recognized as a satisfactory money saving source of lime for both interior and exterior plaster. The plasticity, or spreading quality of such plaster made with carbide lime is said to be superior to that of plaster made with ordinary hydrated lime. It works more smoothly under the trowel and it is commonly stated that plaster made from carbide lime does not "buckle" or "pit". Carbide lime is usually relatively low in magnesium.

STUCCO: Authorities on the subject declare that stucco, made simply of a mixture of hydrated lime and sand, where properly mixed and applied, is practically everlasting. By-product calcium hydrate has been used successfully in the preparation of stucco.

Carbide is also useful in the production of Masonry cement, concrete, refractory bricks, sand-lime brick, cinder brick precast cinder and concrete blocks. It is also used for the protection of underground pipe lines, stabilization of day soil road beds, laying of brick pavements.

(iv) USE IN THE FIELD OF AGRICULTURE [8]

Soil conditioning: Lime is applied to land extensively in the form of hydrate lime and limestone. It serve primarily as a corrective conditioner and secondarily to supply plant-food. By - product calcium hydrate from acetylene generation is a satisfactory liming agent and is not difficult to distribute on the land when of a satisfactory degree of dryness.

Soil is a complex material possessing varying chemical, biological and physical properties. The effect of lime on soils varies with the character of the soil. Lime applied to the soil accomplishes the following benefits.

(i) Neutralization of soil acidity

(ii) Promoting the activity of beneficial bacteria and depressing injurious soil organisms

(iii) Replenishing the supply of calcium

(iv) Improving the texture of the soil

(v) Hastening the decay of organic matter and the formation of Nitrate.

(vi) Acting as a germicide in killing certain soil borne organisms.

2.4.4 FORMULAS FOR LIME MIXTURE [8]

(i) **Lime Sulphur Spray:** Lime sulphur, one of the best fungicides for trees, is prepared by heating sulphur with milk of lime.

Direction for making 50gal. of lime sulphur spray are as follows:

Sulphur (wettable)	8lb
Carbide lime	3 gal.
Calcium arsenate	80z
Water	40 gal.

(approximately 50% solid)

Procedure:- Heat about 1/3 of the total amount of water, adding the sulphur slowly to make a thick paste. When the water is hot, add all the carbide lime, and thoroughly stir. Mix and add another third of water and continue to cook and stir for about 45 to 60 minutes until a clear, orange - coloured solution is obtained. Then add the rest of the water and the calcium arsenate. Let the mixture settle and run it through a fine sieve as it is poured into the spray tank. This should be diluted in a ratio of about six part water to one part of solution.

(ii) **White-Wash:** White wash is used as a decay retarder because of its antiseptic property. It is used for the coating of walls & ceilings of shops, storerooms, roundhouses etc. There are two practical & simple white wash formulas

Interior Whitewash: The formula is said to be recommended because of its fire retarding qualities.

(1) Mix 160lb of 50 percent solids carbide lime with water to a creamy consistency.

(2) Mix 2½ lb of flour thoroughly with ½ gal. of cold water, and then thin with 2 gal. boiling water.

(3) Dissolve 2½ lb of common salt in 2½ gal of hot water. Mix (2) and (3) then add (1) and stir until well mixed.

Exterior weather proof white wash:

Formula A

(1) Mix 160lb of 50% solid carbide lime with water to creamy consistency.

(2) Dissolve 2lb of common salt and lb of sulphate of zinc in 2 gal of boiling water

(3) Provide 2 gal of skimmed milk

Pour (2) into (1) then add (3) and stir well

Formula B

(1) Mix 20 lb of 50% solid carbide lime to a creamy consistency with water.

(2) Dissolve 1lb of carbonate of soda in 1/4 gal of boiling water.

(3) Soak in cold water for at least 8 hours 1/4 lb of common glue and 1lb of rice flour, then thoroughly dissolve the glue mixture in 3/4 gal more water in a double boiler mix (1) with (2), then add (3).

Maryland formula

The following formula is used quite universally in the making of exterior white wash. This wash may be slightly brown in colour but whitens after application.

Hydrated lime	½ bag
Common salt	6 lb
Molasses	1 pint
Ground alum	$3O_2$
Hot water	10 gal

Advantages of additives to whitewash formulas

Alum prevents its rubbing off, flour paste will also prevent it rubbing off but zinc sulphate must be used as preservative. Molasses cause lime to penetrate wood & plaster better. One pint of molasses to 5 gal of whitewash is generally considered sufficient. A solution of silicate of soda or water glass, makes what is commonly referred to as "fire proof cement" of whitewash.

CHAPTER THREE

3.0 EXPERIMENTAL WORK

3.1 EXPERIMENTAL PROCESSES

A. SEDIMENTATION PROCESS: Sedimentation of carbide – sludge implies the concentration of its solid content by the removal of water. Carbide lime slurry (10 – 12% solid) was collected in the sedimentation tank and allowed to settle for one week, after which two clear phases were obtained and consequently separated by decanting 45 – 50% solid content was obtained.

B. PRESSING PROCESS: Pressing is another process of water removal. The paste obtained was pressed with the aid of a filter bag.

C. DRYING PROCESS: Removal of moisture content by way of evaporation. The wet solid obtained from B was sun-dried.

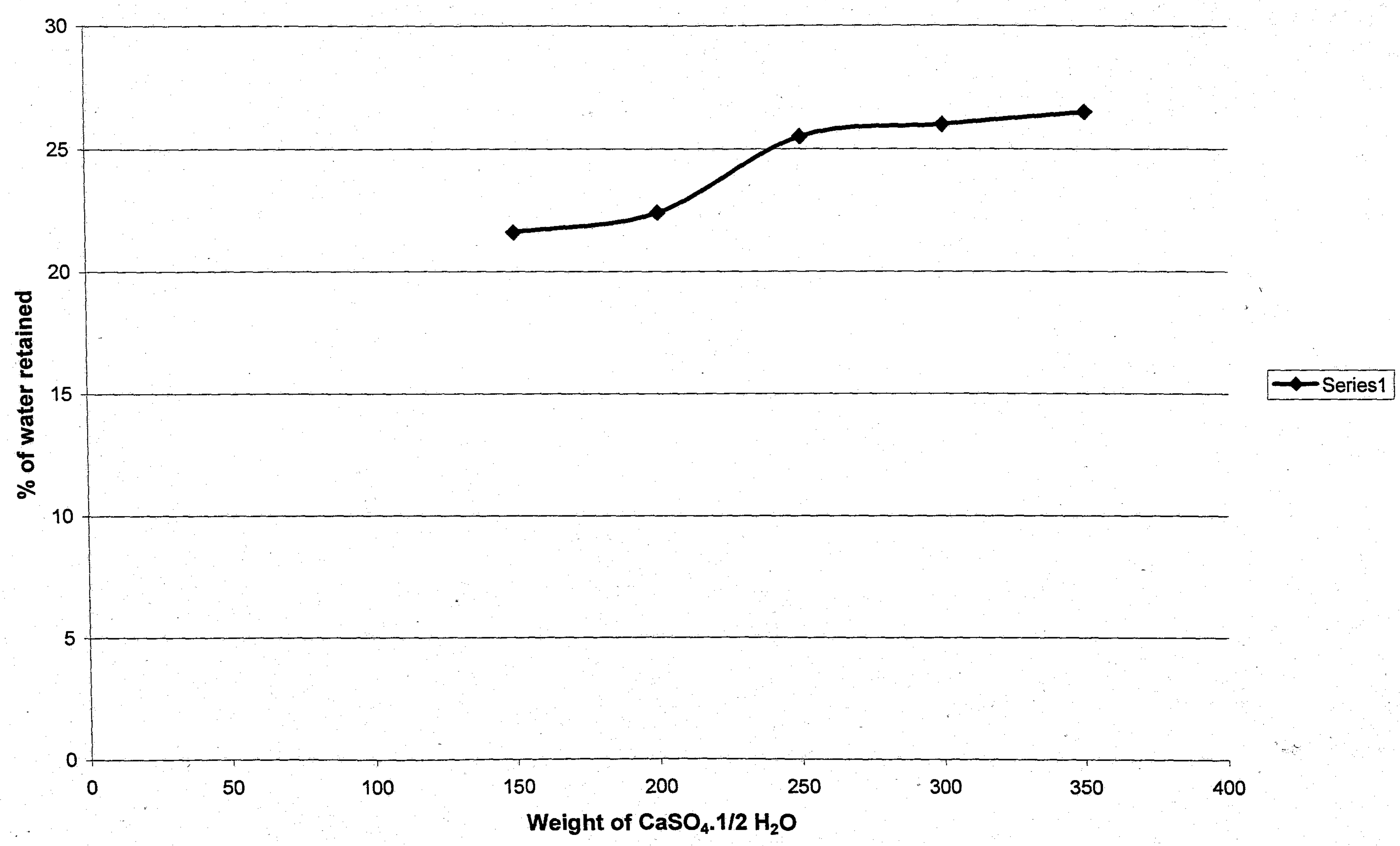
D. CRUSHING & GRINGING PROCESSES: The dry cake was crushed to obtain fine particle size. Grounded lime hydrate was sieved to obtain different particle sizes.

E. WEIGHING PROCESS: Carried out to obtain different weights, with the aid of an electronic balance.

F. MIXING PROCESS:- $Ca(OH)_2$, $CaSO_4.\frac{1}{2}H_2O$, & water were mixed to obtain an homogenous mixture.

G. MOULDING PROCESS: Casting of thick paste into the cast-iron mould to obtain well rounded & tapered chalk sticks.

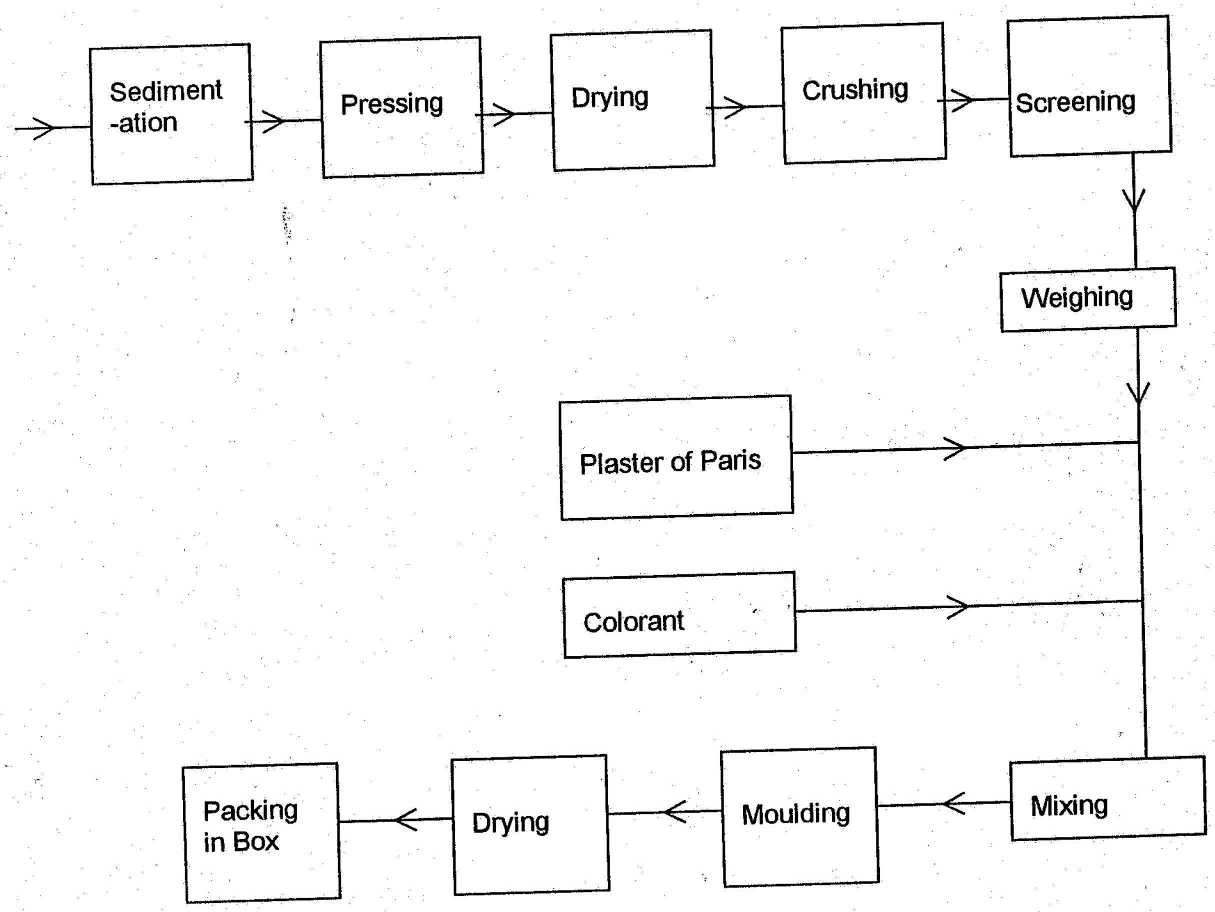
Fig 3: Graph of % water retained vs weight of $CaSO_4.1/2\ H_20$



3.2 EXPERIMENTAL PROCEDURE

1. Carbide lime slurry was concentrated to 45 – 55% (solid) by sedimentation.
2. The paste obtained was further concentrated to 80% solid content by pressing.
3. The wet solid obtained was sun-dried for 20hrs.
4. The dry cake was then crushed and grounded and sieved to obtain different particle sizes.
5. The mould was cleaned and lubricated.
6. Different weights hydrate – lime ($Ca(OH)_2$ & P.O.P [$CaSO_4$ (H_2O)] were weighed & labeled (A_1 to E_1, A_2 to E_2 respectively)
7. 500g of distilled water was also weighed
8. A_1 was added to A_2 and 500g of distilled water gradually added to produce an homogenous mixture which was immediately poured into the mould and allowed to set for 12-15 minutes.
9. The chalkstick was then pushed out of the cavity using the piston and subsequently dried and weighed.
10. (5) (7) (8) & (9) was repeated for B_1 & B_2, C_1 & C_2 --- --- E_1 & E_2.

3.3 CONCEPTUALIZED FLOW PROCESS FOR CHALK PRODUCTION FROM LIME SLUDGE.



3.4.1 TABLE OF RESULT

Very high .... < < <

High... < <

Low... > >

Very low.. > > >

Average.. <

BEST OUTPUT REQUIREMENT

Writability – Very high (> > >)

Hardness - Average (>)

TABLE 3.1 OUTPUT QUALITY

$CaSO_4 \cdot ½ H_2O$ (kg)	150	200	250	300	350
$Ca(OH)_2$ (kg)	250	250	250	250	250
Writability	<<<	<<	<<	>>	>>
Hardness	>>	>>	>	<<	<<<

3.4.2 RESULT OF THE EXPERIMENTS ARE PRESENTED IN TABLE 3.2 AND 3.3

TABLE 3.2.0 OVEN – DRIED (AT 120^{0}C FOR 7HRS)

WEIGHT IN KILOGRAMS						
SAMPLE	**$Ca(OH)_2$**	**CaSO4.1/2 H_2O**	**WATER**	**WEIGHT ON DRYING**	**WATER CONTENT ON DRYING**	**% WATER RETAINED**
A	250	150	400	510	110	21.60
B	250	200	450	580	130	22.40
C	250	250	500	670	170	25.50
D	250	300	550	743	193	26.00
E	250	350	600	816	216	26.50

TABLE 3.3 SUN – DREID (20 HRS AT ATMOSPHERIC TEMPERATURE)

WEIGHT IN KILOGRAMS						
SAMPLE	**$Ca(OH)_2$**	**CaSO4.1/2 H_2O**	**WATER**	**WEIGHT ON DRYING**	**WATER CONTENT ON DRYING**	**% WATER RETAINED**
A	250	150	400	511	111	21.70
B	250	200	450	578	128	22.10
C	250	250	500	672	172	25.60
D	250	300	550	741	191	25.80
E	250	350	600	816	217	26.40

3.5.0 BATCH PRODUCTION OF 1000KG OF CHALK

MATRIAL & SPECIFICATION

Ca $(OH)_2$	372.5 kg
$CaSO_4 . \frac{1}{2} H_2O$	372.5 kg
Water	745 kg
Pigment	2.5
	1492.5 kg

CHAPTER FOUR

4.0.0 DISCUSSION OF RESULTS

Processing of carbide sludge into dry lime hydrate gave a dry powder, which is grayish in colour, not very white, as lime obtained from other processes. This is as a result of impurities such as combined sulphur present in the slurry (Table 2.2.1).

EFFECT OF METHOD OF DRYING

It was observed that the sun-dried chalk had a brighter appearance than the oven-dried chalk, this is a result of slight conversion of Ca $(OH)_2$ to $CaCO_3$.

At a temperature of 120^0C drying time is 7hours and 20hrs when sun-dried.

In most commercial application, the chalk is usually oven-dried to save time.

EFFECT OF $CaSO_4$. ½H_2O ON BINDING STRENGTH

The setting (time taken to form crust) decreased with increasing concentration of $CaSO_4$.½.H_2O. The percentage water retained is indicative of the binding strength, for higher concentration $CaSO_4$.½.H_2O, to Ca $(OH)_2$, more water was retained and for the range of values taken, it was highest at 26.5% water and at lower $CaSO_4$:½.H_2O (21.6%) indicating that higher compositions of $CaSO_4$.½.H_2O favour water retention. (Table 3).

In most commercial application, employ the use of $CaSO_4$. ½H_2O because of its strong binding property and whiteness. ( )

EFFECT OF $CaSO_4$.½.H_2O ON HARDNESS

It was discovered that as the concentration of $CaSO_4$.½.H_2O increases, the hardness of the chalk increases and writability decreases. Equal fractions of Ca $(OH)_2$ & $CaSO_4$.½.H_2O, was found to be optimum.

From literature, when $CaSO_4.\frac{1}{2}.H_2O$ is used as sole raw material in chalk production, retarders are added to minimize the rate of hardening of the chalk. ( )

EFFECT OF PARTICLE SIZE

Binding property of chalk depends on the particle size, it was observed that as the particle size increased the binding property decrease. Optimum particle size will be determined by comparing the cost of size reduction to output quality. A sieve size of 300mm was used.

EFFECT OF PIGMENTS

The use of large quality of pigments yielded bad result, smaller quantities are preferable. The most type of pigment use are White lead, Zinc oxide and lithophone (White) and lead chromate, iron oxide of transition metals (colour) A small percentage of about 1% is used in most commercial production of chalks. ( )

4.1.0 PROPOSED TECHNOLOGY OF PRODUCTION

(a) The dry lime hydrate powder should be pulverized.

(b) A chalk-making machine should be used.

(c) Could be sun-dried to reduce cost (about 20 hrs).

THE PROCESS SHOULD COMPRISE

1 Measurement of clear water

2 Measurement of Dry lime hydrate and plaster of Paris

3 Stirring

4 Injection of moulding agent

5 Drawing of chalk from designated grams.

6 Transfer of drawn chalk on shelf for drying, and

7 Transfer of chalk to the place for drying and maturing consumption of clean water and dry solids for 500 pieces of chalk dryer.

H_2O, 2, 350g - per dryer

Ca $(OH)2$, 1175g - per dryer

$CaSO_4.½.H_2O$, 1175g - per dryer

8. Transfer of semi-finished goods, after completion of drying for the finishing process.

9. Packaging- packaging in cartons after the packaging of 100 pieces to case and

10. Transfer to the shipping section in the warehouse for storage as finished goods and shipment.

DESCRIPTION OF CHALK MAKING MACHINE

Model: M-600

The school chalk-making machine contains 600 round brass tubes for chalk molding. One mold will produce 600 pieces of chalk at about 15-20 minutes.

This machine is manipulated manually, no electric fuel are necessary.

Machine dimension: L.39" W.24" H.34 ½"

Net weight: 220kgs

Accessories:

For each set of school chalk making machine

Oil brush 1 piece

Brass scrapper 1 piece

Oil box: 1 piece

Wooden drying trays (for sunlight drying) 3 pieces.

Raw Materials.

1. Dry Powder 2.7kg/per mold/ 600 pcs of chalk. (Equal weight of $Ca(OH)_2$ and $CaSO_4.½.H_2O$)
2. Water-soluble pigment for making colour chalks.
3. Mold releasing agent: Mineral oil mixed with vegetable oil.

   Drying method: By sunlight about 20hrs, or By drying oven about 7hrs.

APPENDIX

CALCULATIONS

(1) CALCULATION OF PERCENTAGE OF WATER RETAINED

Given,

Weight of water = 400g

Weight of Ca (OH_2) = 250g

Weight of $CaSO_4$. H_2O = 150g

Total weight = 800g

Final weight = 510g

Weight of water dehydrate = Total weight of mixture – final weight

800 – 510 = 290g

Weight of water retained = 400 – 290

= 110g

% of water dehydrated $= \frac{290}{400} \times 100 = 72.5\%$

% of water retained $= \frac{110}{400} \times 100 = 27.5\%$

% of water retained in chalk $= \frac{110}{510}$ 21.6%

% Water retained in B, C, D & E are obtained to be 22.4%, 25.5%, 26.0% & 26.5% respectively.

DENSITY

Weight of 20 pieces of chalk = 17.5g

Volume of 20 pieces of chalk = $12cm^3$.

Density $= \frac{17.5}{12} = 1.46g/cm^3$

BATCH PRODUCTION OF 1000kg CHALK

1000kg of mixture	=	670kg of chalk
xg " "	=	1000kg of chalk

x = 1492.5 kg.

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